Mars Exploration Program (MEP) Update

Presented to the Planetary Protection Subcommittee
Dec 8, 2015

Jim Watzin
Director Mars Exploration Program

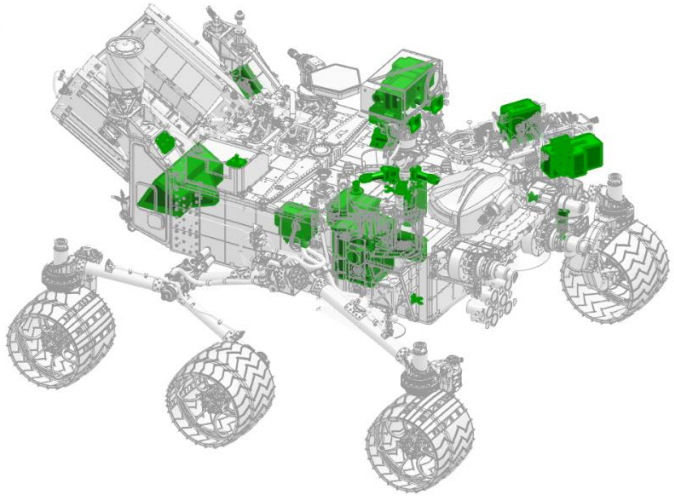
#JOURNEYTOMARS

MEP Update

- **Ongoing efforts**
  - Operational assets continuing to support mission objectives
  - Mars 2020 development proceeding well, nearing PDR
    - Many subsystem reviews already complete
  - MOMA recently delayed due to late delivery of DLR laser
- **Long term**
  - Increasing need to replace and update aging infrastructure
  - Responding to NRC Decadal Survey science priority of MSR requires additional missions
    - The 2022 opportunity 5 years from the current budget planning horizon
- **Science/Exploration collaboration**
  - MEPAG NEX-SAG study complete
  - Joint MEP/HEOMD Human Landing Site Workshop conducted

Mars 2020 Update

- Conducted 2nd Landing Site Workshops in August 2015; ongoing imaging and analysis for top sites
- Completed Heritage Flight System Review in September 2015
- Early acquisition and builds of heritage elements and items with low risk of change are proceeding at a fast pace
- Completed Sampling & Caching System (SCS) architecture definition. Working detailed engineering and design for cache system implementation
- Continue working with PPO to finalize the Categorization Letter and PP Plan
- Payload instrument and flight system preliminary design reviews (PDRs) ongoing, culminating in Project PDR in February 2016
  - Completed CEDL, Mastcam-Z, SuperCam, RIMFAX, MEDA, TRN, and Sampling/Caching System PDRs
  - Surface Operations, PIXL, SHERLOC, and MOXIE PDRs scheduled for December-January
- On track for Feb 2016 PDR



Project has made excellent progress to date

MOMA-MS Project Description

Project Description: Delivery of key subsystem to international PI as a part of an ESA Planetary Science mission to explore signs of present/past life on Mars (dual-source mass spectrometer); Class C

Science Objectives:

- MOMA addresses the ExoMars top science goal of seeking signs of past or present life on Mars
- MOMA-MS is a subsystem of MOMA composed of a dual source mass spectrometer to detect a wide range of organic molecules in Martian samples. Organic structure and distribution can be indicators of life

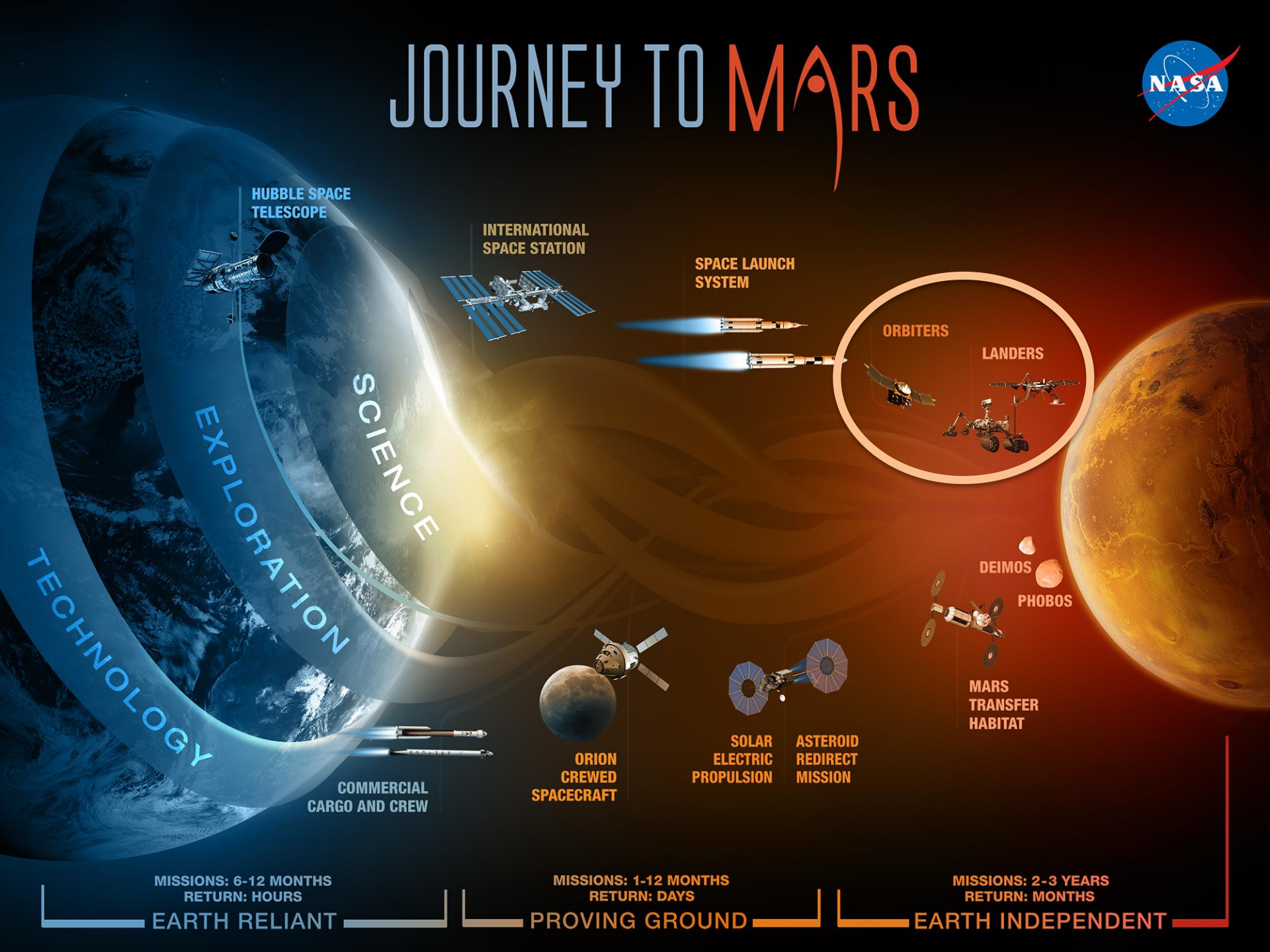
Organizational Contributors:

- ExoMars Mission Lead: European Space Agency
- ExoMars Analytical Lab Drawer: Thales Alenia Space –Italia (TAS-I)
- MOMA PI: Max Planck Institute for Solar System Research
  - Gas Chromatograph: LISA/LATMOS (France)
  - Laser: Laser Zentrum Hanover (LZH)
  - Electronics: University of Michigan, Battel Engineering
  - Wide Range Pump: Creare

Overall Status:

- Re-baselined MOMA design to require only LD/MS capabilities due to late delivery of GC from CNES
  - GC option to be kept open as long as possible
- DLR/Max Planck recently informed MOMA team of significant slip in delivery (from Laser Zentrum) and integration (by Max Planck) of flight system laser. Unless resolved, this may push MOMA FM delivery to early 2017 - a major risk to MOMA project ability to meet 2018 ExoMars launch schedule
- Flight MS in **LDMS** mode (ETU laser)
  - Instrument performance (tested so far) is excellent – very clean spectra
- ESA selected Oxia Planum as the landing site for ExoMars 2018

JOURNEY TO MARS



MISSIONS: 6-12 MONTHS
RETURN: HOURS
EARTH RELIANT

MISSIONS: 1-12 MONTHS
RETURN: DAYS
PROVING GROUND

MISSIONS: 2-3 YEARS
RETURN: MONTHS
EARTH INDEPENDENT

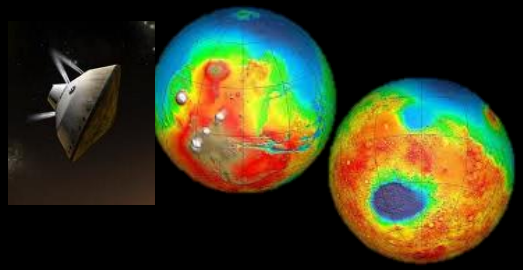
What We've Learned and Still Need to Learn at Mars

Orbital environment and operations

Learned:
- Deep space navigation
- Orbit transfer near low-gravity bodies
- Gravity assist
- Aero-braking
- Gravitational potential
- Mars' moons characteristics
- ISRU potential

To Learn:
- Return flight from Mars to Earth
- Autonomous Rendezvous & Docking
- ISRU feasibility
- Resource characterization of Mars moons
- High-power SEP

Capture, EDL & Ascent at Mars



Learned:
- Spatial/temporal temperature variability
- Density and composition variability
- Storm structure, duration and intensity
- 1 mT Payload
- ~10 km Accuracy

To Learn:
- Ascent from Mars
- Large mass EDL
- Precision EDL
- Aero-capture
- Site topography and roughness
- Long-term atmospheric variability

Surface Operations at Mars

Learned:
- Water once flowed and was stable
- Global topography: elevation and boulder distributions
- Remnant magnetic field
- Dust impacts on Solar Power / Mechanisms
- Radiation dose
- Global resource distribution
- Relay strategies, operations cadence

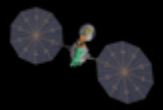
To Learn:
- Landing site resource survey
- Dust effects on human health, suits & seals
- Rad/ECLSS in Mars in environment
- Power sufficient for ISRU
- Surface Navigation

Resource prospecting and round trip experience are key enablers

Conceptual Integrated Campaign for Mars Precursors “in the 2020s”

LEGEND

- Exploration
- Cross-Cutting (Exploration-Technology-Science)
- Science

Mars 2020	Mars Orbiter	Round-Trip Surface to Surface	Exploration Precursors
			
ISRU Prototype	Resource Survey	Dust Toxicity	ISRU Production
EDL Instruments	Landing Site Selection	EDL Evolution/ Instruments	Surface Power for ISRU
Sample Acquisition	Optical Comm/Relay	Mars Ascent	Rad/ECLSS Validation
In Situ Science	SEP	Surface Navigation	Increased EDL Mass & Precision
Habitable Conditions	Rendezvous	Returned Sample Analysis	Science Instruments
Ancient Life	Remote Sensing Instruments		

Robotic precursors pursuing round-trip objectives intrinsically inform strategic exploration planning by providing invaluable flight experience

Science Exploration Integration

How can these objectives be pursued?

ICE Working Group

ISRU & Civil Engineering

Co-Chairs: S. Hoffman, R. Mueller
Ex Officio: Bussey, Davis

HSO-SAG

Human Science Objectives

Co-Chairs: D. Beaty, P. Niles
Ex Officio: Bussey, Davis, Meyer

HLS²

Human Landing Site Study
Coordinators:
Davis, Bussey, Meyer

What are the Base & Exploration Zone criteria? What & where are the resources needed?

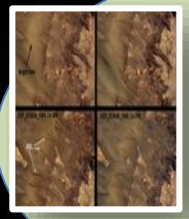
Where & what should humans explore

NEX-SAG

Next Orbiter Options

Co-Chairs: R. Zurek
Ex Officio: Meyer, Bussey

NRC Planetary Decadal Survey



MEPAG Goals

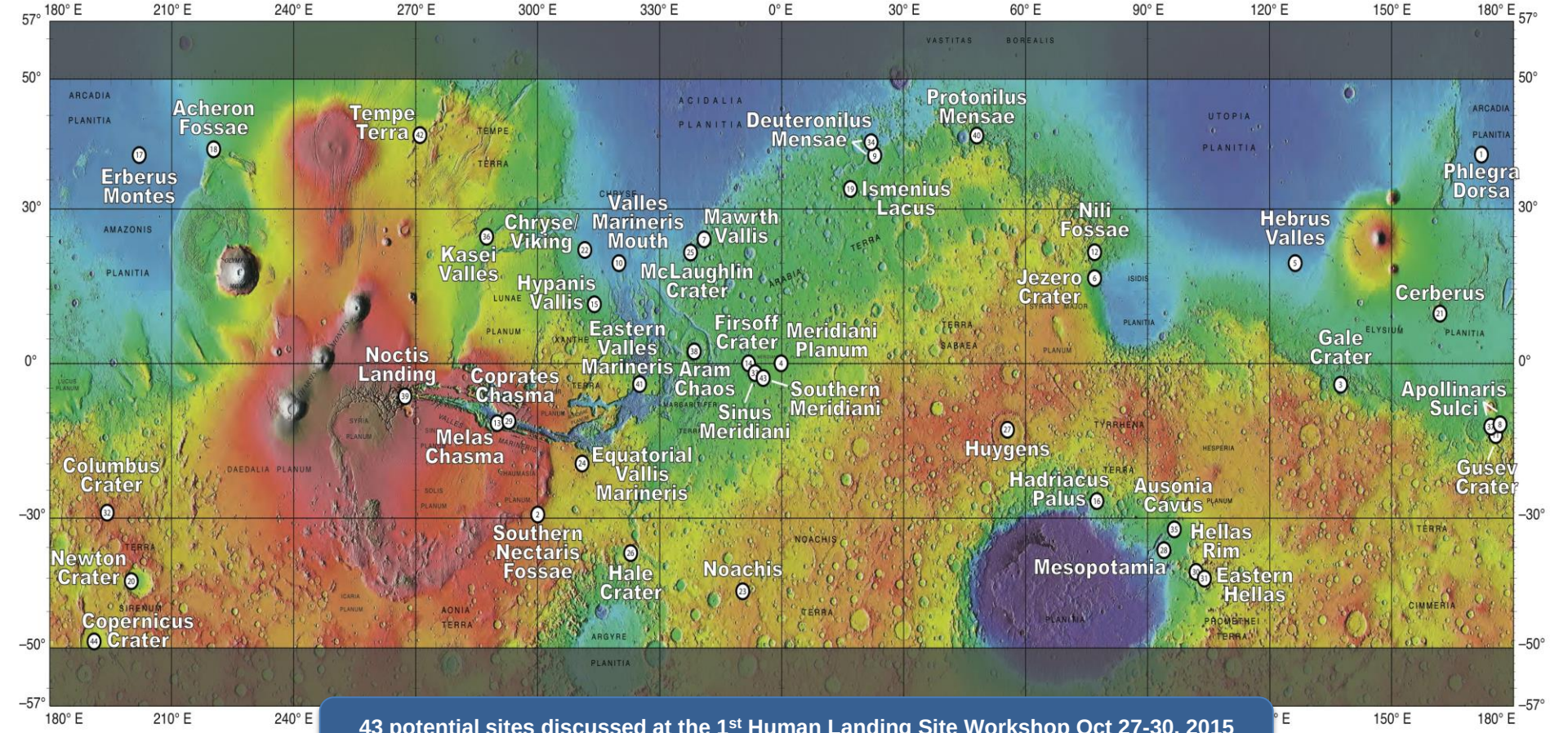
Science Objectives

Next Orbiter (NEX-SAG) Findings

- SEP brings the advantages of orbit flexibility and increased payload mass & power
- Advanced telecom provides necessary coverage for high-resolution data
- Considerable overlap between science goals and human exploration resource prospecting interests & derived objectives yield similar, mature instrument approaches
  - **Visible imaging** *of HiRISE-class or better (~15-30 cm/pixel)*
  - **Polarimetric synthetic aperture radar** *imaging with penetration depth of a few (<10) meters and spatial resolution of ~15 m/pixel to search for shallow ground ice and crustal structure*
  - **Short-wave IR spectral** *mapping with a spatial resolution of ~6 m/pixel (3 x CRISM) with sufficient spectral resolution to detect key minerals*
  - **Long-wave atmospheric sounding** *for wind, temperature, & water vapor profiles with 5 km vertical resolution*
  - **Thermal IR sounding** *for aerosol (dust & ice) profiles*
  - **Multi-band thermal IR** *mapping of thermo-physical surface properties (e.g., ice overburden) and surface composition*
  - **Wide-angle imaging** *to monitor weather and surface frosts (global, km-scale)*

MARS

Potential Exploration Zones for Human Missions to the Surface of Mars



43 potential sites discussed at the 1st Human Landing Site Workshop Oct 27-30, 2015
- Consensus that understanding resources is crucial input -

Exploration Zones proposed for humans to Mars. At the equator, circles are ~100km radius

Prepared By: Lindsay Hays, Mars Program Office
lhays@jpl.nasa.gov

MARS

Mars Exploration Program Status Summary

- MEP is healthy
  - Meeting our development milestones
  - Collaboration with Exploration helping to frame future
  - Operational assets, though aging, continue to support mission needs
- Planning for the future continues to be a pressing priority

"Panorama compliments of the Curiosity rover"
9 Sept 2015